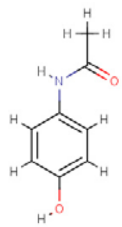
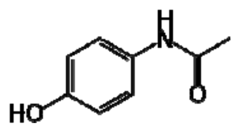
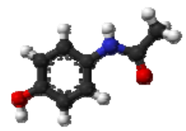
Organic Chemistry

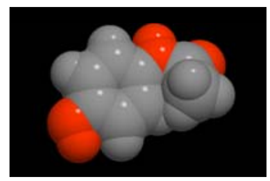
- Many compounds are built around the carbon atom
  - Organic Chemistry focuses on these compounds
    - Contain carbon and other atoms such as H, O, N, S, P…
    - >10 million compounds
  - Natural or “synthetic”
  - Huge variety due to many bonding possibilities for carbon

- Approaches for representing organic compounds
  - Examples: hexane, acetaminophen ($C_8H_9NO_2$)









Functional Group Chemistry

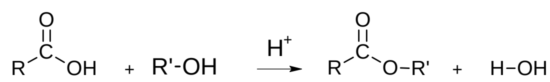
- Even though there are many organic compounds, it is possible to categorize compounds by looking at how the atoms are arranged
  - **Functional Group** – portion of a compound that has a characteristic arrangement of atoms and characteristic properties and reactivity.

- Functional Groups are the key to understanding organic chemistry!

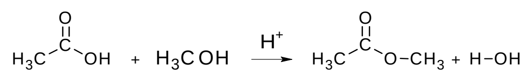
Functional Group	Formula	Structure	Properties
Alkane	C-C and C-H single bonds		
Alkene	R_2-C=C-R_2		
Alkyne	R-C≡C-R'		
Alcohol	R-OH		
Ether	R-O-R'		

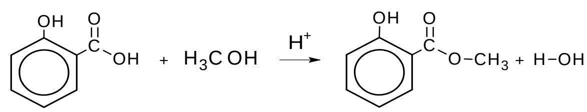
Functional Group Chemistry

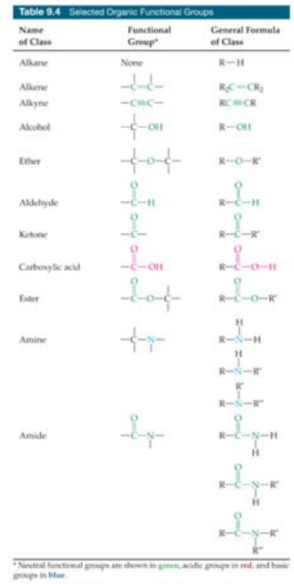
- Because of common reactivity of functional groups, it is possible to predict reactivity of organic compounds
- EXAMPLE: Ester formation: Esters can be formed by the dehydration reaction of an alcohol and a carboxylic acid.



- "R" can be any group



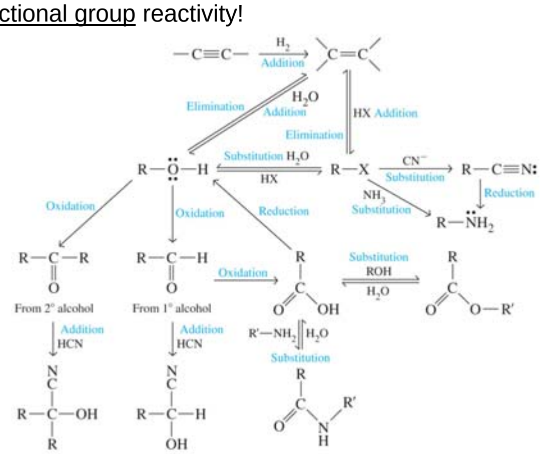




Functional Group Chemistry

So, we can build larger, more complicated molecules by taking advantage of functional group reactivity!

- Regardless of whether we're talking about small molecules like methanol or huge molecules like proteins, behavior typically boils down to functional group reactivity!



Identification and Naming of Organic Compounds

Two key criteria

1. Types of functional groups present
2. Length of carbon backbone
   - Prefix tells length of carbon chain
   - Virtually any organic compound can be named based on rules developed from these criteria.

Name	Molecular Formula	Structural Formula	Isomers
meth**ane**	CH_4	CH_4	1
eth**ane**	C_2H_6	CH_3CH_3	1
prop**ane**	C_3H_8	$CH_3CH_2CH_3$	1
but**ane**	C_4H_{10}	$CH_3CH_2CH_2CH_3$	2
pent**ane**	C_5H_{12}	$CH_3(CH_2)_3CH_3$	3
hex**ane**	C_6H_{14}	$CH_3(CH_2)_4CH_3$	5
hept**ane**	C_7H_{16}	$CH_3(CH_2)_5CH_3$	9
oct**ane**	C_8H_{18}	$CH_3(CH_2)_6CH_3$	18
non**ane**	C_9H_{20}	$CH_3(CH_2)_7CH_3$	35
dec**ane**	$C_{10}H_{22}$	$CH_3(CH_2)_8CH_3$	75

Organic Nomenclature

IUPAC Rules for Alkane Nomenclature:

1. Find and name the longest continuous carbon chain.
2. Identify and name groups attached to this chain.
3. Number the chain consecutively, starting at the end nearest a substituent group.
4. Designate the location of each substituent group by an appropriate number and name.
5. Assemble the name, listing groups in alphabetical order.

The prefixes di, tri, tetra etc., used to designate several groups of the same kind, are not considered when alphabetizing.

Alkyl Substituents:

Group	Name	Group	Name
CH_3–	Methyl	$CH_3CH_2CH_2CH_2$–	Butyl
C_2H_5–	Ethyl	$(CH_3)_2CHCH_2$–	Isobutyl
$CH_3CH_2CH_2$–	Propyl	$CH_3CH_2CH(CH_3)$–	sec-Butyl
$(CH_3)_2CH$–	Isopropyl	$(CH_3)_3C$–	tert-Butyl

Isomers

Isomers: different compounds with same molecular formula

Stereoisomers: isomers where connections are same, but arrangement in space different

Constitutional Isomers: isomers where atoms are connected differently

Enantiomers: stereoisomers that are mirror images

Diastereomers: stereoisomers that are not mirror images

EXAMPLE: $C_2H_2Cl_2$ has 3 possible structures, only 2 are diastereomers

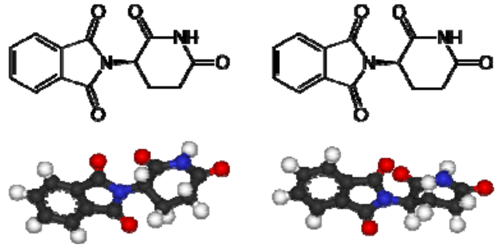
Enantiomers

Molecules that have Enantiomers are Chiral

- Amino Acids are one Enantiomer
- Some bacteria use the amino acids of the other chirality to trick their hosts

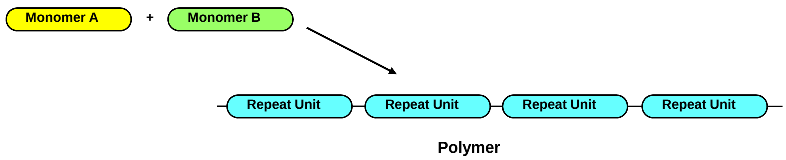
Enantiomers have similar physical properties (nearly identical)

- Interact differently with polarized light
- May have dramatically different reactivity
  - Thalidomide



Polymer Chemistry

"Big" molecules, but the result of several functional group reactions



Polymer properties depend on several factors, including:

- the chemical composition of the monomer units,
- length of the chain,
- the three dimensional arrangement of the chains in the solid,
- the branching in the chain,
- the bonding/interaction between chains,

Plasticizers:

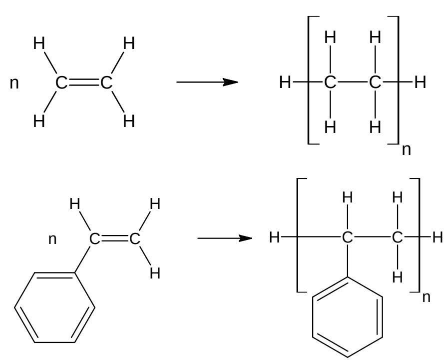
Crosslinking:

Polymerization Reactions

Two major classes of polymerization reactions: Addition and Condensation

Addition Polymerization – no other products are formed

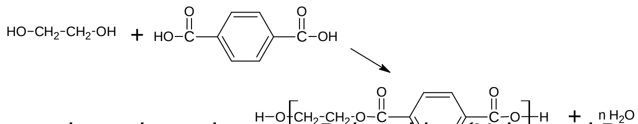
Examples: polyethylene and polystyrene



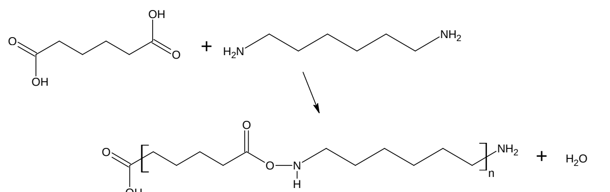
Polymerization Reactions

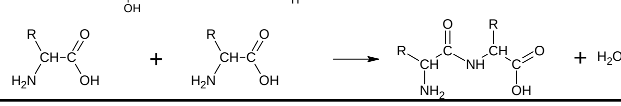
Condensation Polymerization – small molecules are produced as byproducts

Example: Polytehylene Terephthalate (PETE)



- *More condensation polymers – Polyamides (Nylon and Proteins)*





The Big Six

Table 9.1

The Big Six (Including Identifying Code of the Polymers)

Polymer	Monomer	Properties of Polymer	Uses of Polymer
Polyethylene (LDPE) 4 LDPE	Ethylene	Opaque, soft, flexible, impermeable to water vapor, unreactive toward acids and bases, absorbs oils and softens, melts at 100°–120°C, does not become brittle until −100°C, oxidizes on exposure to sunlight, subject to cracking if stressed in presence of many polar compounds	Plastic bags, toys, electrical insulation
Polyethylene (HDPE) 2 HDPE	Ethylene	Similar to LDPE, more opaque, denser, mechanically tougher, more crystalline and rigid	Milk and water jugs, gasoline tanks, cups
Polyvinyl chloride 3 V	Vinyl chloride	Rigid, thermoplastic, impervious to oils and most organic materials, transparent, high impact strength	Plumbing pipe, garden hoses, "bubble" package wrap
Polystyrene 6 PS	Styrene	Glassy, sparkling clarity, rigid, brittle, easily fabricated, upper temperature use 90°C, soluble in many organic materials	Styrofoam insulation, inexpensive furniture, drinking glasses
Polypropylene 5 PP	Propylene	Opaque, high melting point (160°–170°C), high tensile strength and rigidity, lowest density commercial plastic, impermeable to liquids and gases, smooth surface with high luster	Battery cases, indoor-outdoor carpeting, bottle caps, auto trin
Polyethylene terephthalate 1 PETE	Ethylene glycol $HOCH_2CH_2OH$; Terephthalic acid	Transparent, high impact strength, impervious to acid and atmospheric gases, not subject to stretching, most costly of the six	Clothing, soft-drink bottles, audio- and videotapes, film backing